MASTER OF SCIENCE IN MECHANICAL ENGINEERING

THEORETICAL INVESTIGATION OF ROTOR ACCELERATION SCHEDULING THROUGH CRITICAL SPEED

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An analytical investigation was conducted to study the amplitude of lateral vibrations and vibrational energy and power of an unbalanced rotor passing through its first lateral bending critical speed. A two degree-of-freedom lumped mass, damping and stiffness model was developed to simulate the response of a simply supported, single disk rotor. Given an arbitrary input acceleration or deceleration, the equations of motion were solved numerically using a fourth order Runge-Kutta routine. The routine used a time step that corresponded to a constant angular phase of rotation. The relationship between the forcing function and lateral vibrational velocity was determined in order to predict the instantaneous power input to the rotor due to the unbalanced rotor. The computer model incorporating an acceleration schedule yielded a result that predicts acceleration scheduling in the location about the critical speed is unable to lower the amplitude of lateral vibrations.

KEYWORD: Accelerating Rotor

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Modeling and Simulation

MEASUREMENT OF SYNCHRONOUS FORCES AND FLOW NON-UNIFORMITY IN AN AXIAL COMPRESSOR

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Time resolved pressure measurements on a compressor case were acquired for several uniform and non-uniform tip clearances. High frequency response pressure transducers were placed at several axial locations near the second stage axial rotor on the outer casing of an Allison C-250 compressor. Data were acquired at several fixed time intervals. The amplitude of the blade-to-blade variations and once per revolution static pressure distributions on the case were recorded for an "as is" compressor. The synchronous forces due to possible imperfections were determined using a high hub-tip ratio assumption.

KEYWORDS: Turbomachinery, Rotor Dynamics

DoD KEY TECHNOLOGY AREAS: Other (Turbomachinery, Rotor Dynamics)

MODEL FOR ESTIMATION OF THERMAL HISTORY PRODUCED BY A SINGLE PASS UNDERWATER WET WELD

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Thermal history calculations for single pass underwater wet weldments were made by solving the appropriate heat transfer equations using the three-dimensional Crank-Nicholson finite difference method. The Adams approach, which defines the fusion line temperature as a boundary condition, was adopted. Tsai and Masubuchi's semi-empirical correlation, defining the surface heat transfer coefficient of underwater weldments, was used to determine the heat loss through the surface of the welded plate. As expected, the calculated cooling rates in heat affected zones (HAZs) of underwater wet welded ferritic steels were found to be somewhat faster than equivalent cooling rates calculated for the same weldments generated in air. However, the effect of water temperature on cooling times in the HAZ between 800° and 500°C (the parameter conventionally used to measure the cooling rate in the HAZ) was found to be minimal. These calculations suggest that HAZ microstructure of underwater wet welded ferritic steels should be independent of water temperature. This prediction was confirmed by microstructural studies of samples of ASTM A516 grade 70 steel which were underwater wet welded at water temperatures of 31°, 10° and 3°C respectively and for which similar HAZ microsructures were obtained in each case.

KEYWORDS: Underwater Wet Welding, Modeling of Heat Transfer in Welding

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

A MODEL FOR DEFORMATION OF CONTINUOUS FIBER COMPOSITES UNDER ISOTHERMAL CREEP AND THERMAL CYCLING CONDITIONS

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A model to describe the internal stress and strain states in a continuous fiber composite during thermal cycling and/or isothermal excursion has been developed. The model extends a previously developed model by incorporating the effects of: (1) changing matrix creep mechanisms and (2) fiber-matrix interfacial sliding via diffusional creep. Results from sample calculations incorporating these effects during both thermal cycling and isothermal creep are presented. It is envisioned that such a model will be useful in discerning the predominant matrix creep mechanism at various times for a given applied stress and temperature, and thus enable the generation of transient deformation mechanism maps for the composite.

KEYWORDS: Continuous Fiber, Metal Matrix Composites, Creep Mechanisms, Isostrain, Non-isostrain Deformation, Interfacial Sliding, Deformation Mechanism Maps

DoD KEY TECHNOLOGY AREAS: Materials, Processes, and Structures, Modeling and Simulation

DEVELOPMENT AND CALIBRATION OF A TORSIONAL ENGINE MODEL FOR A THREE-CYLINDER, TWO-STROKE DIESEL ENGINE

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An experimental and analytical investigation was conducted to develop a calibrated torsional model of a three-cylinder, two-stroke diesel engine. A Detroit Diesel 3-53 engine was instrumented for time-resolved measurement of cylinder firing pressures and high resolution near instantaneous shaft speed using a 720 and a 3,600 count per revolution optical encoder. Data were taken for three speeds and three torques for a total of nine conditions. A six degree-of-freedom torsional vibration model of the crankshaft, connecting rods, and pistons was developed. The nonlinear inertias, due to the reciprocating pistons, were included along with linear stiffness and damping. The equations of motion were numerically integrated over a cycle to obtain predicted response. The predicted response was compared to the measured response at the free end of the crankshaft.

KEYWORDS: Diesel, Torsional Vibration Model, Cylinder Pressure Prediction

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Environmental Quality, Ground Vehicles, Modeling and Simulation

COMPUTER SIMULATION OF A TWO-PHASE CAPILLARY PUMPED LOOP (CPL) USING SINDA/FLUINT

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The heat transfer performance of a prototype capillary pumped loop (CPL) test bed from the U.S. Air Force Phillips Laboratory is modeled using numerical differencing techniques. A commercial computer code was used to create the model and simulate performance over a wide range of operating conditions. Steady-state and transient performance were modeled as part of the initial phase of testing in a program designed to evaluate the effectiveness and reliability of capillary pumped loop technology for use in spacecraft thermal control. The performance baseline developed in this phase of testing will serve as the foundation for continued research and development of this technology.

KEYWORDS: Capillary Pumped Loop (CPL), Evaporator, Noncondensible Gas (NCG) Trap

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Modeling and Simulation

MULTIPLE AUTONOMOUS VEHICLES FOR MINEFIELD RECONNAISSANCE AND MAPPING

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The development of numerical search modeling for Autonomous Search Vehicles (ASV's) is an essential tool for development of ASV strategy using groups of small, crawling vehicles. Reconnaissance of surf-zone bottoms for mines and obstacles, as well as providing an environmental mapping capability, is the objective. These models allow numerical simulations to be conducted that determine the relationships between search times, target and obstacle sensing radius, vehicle

speed and numbers of vehicles using simple, preprogrammed search strategies. The results from these simulations on initial models can then be used to determine the overall system performance. More complex models can then be developed using search strategies that include directed search, avoidance behaviors, networking and mapping with sufficient navigational accuracy. With sufficient information on the behavior of these vehicles, the ultimate goal of providing an autonomous reconnaissance and neutralization capability in very shallow water and surf zones can be realized.

KEYWORDS: ASV, Surf Zone Reconnaissance Mission, Simulation, State-Based Robotics

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

DEVELOPMENT OF A CONTROL SYSTEM FOR A SHAPE MEMORY ALLOY (SMA) ACTUATED MEDICAL MANIPULATOR

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This thesis discusses the development of a digital control system used to operate a conceptual robotic manipulator for use in minimally invasive surgery. The motion of the manipulator is envisioned to be accomplished with acutators made of a Shape Memory Alloy (SMA). SMA has the ability to recover permanent deformation by undergoing a phase transformation. The recovery of the deformation results in motion of the SMA material which can be exploited for useful work. SMA was chosen as the actuator because it can be miniaturized and has a very high power density as compared to conventional actuators. An Actuator Matrix Driver (AMD) board was designed, as part of the digital control system, to power and control the SMA actuators. The matrix configuration of the AMD architecture and the use of Amplitude Modulated Pulsed (AMP) current allows for a reduction in the number of leads for the powering and control of the actuators. The electrical resistance, a physical property of SMA which characteristically changes with phase transformation, can be used to determine the state or phase of the SMA actuators and can therefore be used for closed loop control.

KEYWORDS: Shape Memory Alloy (SMA), Actuator Matrix Driver (AMD) Board, Amplitude Modulated Pulsed (AMP) Current

DoD KEY TECHNOLOGY AREA: Sensors